CEO Networks and Information Aggregation: Evidence from Management Forecast Accuracy

ABSTRACT

In this study we provide insight into how CEOs aggregate information from different sources to accurately forecast earnings by examining the relation between CEO networks and management forecast accuracy. We find that larger CEO networks improve the accuracy of firm's earnings forecasts. Our results are robust to controlling for CEO ability and using CEO fixed effects. We also find that the relation between CEO network size and forecast accuracy is strongest for connections with insiders and individuals from the same industry and when the firm's earnings have a relatively high correlation with the industry and macro economy, when there is a greater degree of underlying uncertainty, and industry competition is high. These results suggest that CEOs are able to use their contacts to better identify industry and economy-wide trends. Overall, our study contributes to the literature by providing evidence regarding how CEOs obtain information from external sources to improve their forecast accuracy.

JEL classification: G170; M12; M50
Keywords: social networks, management earnings forecast, managerial ability
Data Availability: All data are publicly available from sources identified in the text.

I. Introduction

An important topic in accounting research is to understand how management obtains and processes information to form their earnings expectations as disclosed to the public in the form of an earnings forecast. In this study, we add to this literature by investigating how a CEO's network of personal and professional contacts, a potentially important source of external information, impacts management forecast accuracy. We first examine whether the size of a CEO's network (personal, professional or educational) is associated with increased accuracy. Second, we focus on the CEO's professional contacts and examine the types of contacts and environmental circumstances under which external information sources are likely to be most helpful. By providing empirical evidence on these issues, our study provides insight into the factors that determine the quality of financial information disseminated by the firm.

To address these questions, we use network data compiled by BoardEx to construct measures of the size of the CEO's network contacts. Our procedure generates broad measures that capture the spread of personal relationships that could provide access to external information and perspectives that could help the CEO more accurately forecast future earnings. Prior literature suggests that social and professional interactions promote knowledge transfer (Glaeser, Kallal, Scheinkman, and Shleifer 1992, Jaffe, Trajtenberg, and Henderson 1993). Following this theory, individuals that have a larger network of personal or professional connections are more likely to share information to develop a better understanding of how fluctuating business circumstances influence their firm's cost structure and product demand. This should enable them to more effectively anticipate future changes to the economic environment. We therefore expect that a CEO's network is likely to provide access to a broader set of information that would allow the

firm to generate more accurate expectations regarding future financial performance. For example, a CEO with a larger network could have more formal or informal interactions with executives in the same industry. This would allow the executive to obtain perspective from a larger number of individuals and to use the broader set of information to derive a better understanding of industry or macro level trends and better forecast their firm's financial performance. Therefore, we expect a positive relation between the size of a CEO's network and the accuracy of the firm's earnings forecast.[1]

On the other hand, a CEO has access to internal information through the firm's internal information system that may capture the relevant information.[2] Thus, it is not clear that personal contacts provide information incremental to the firm's internal information system. In addition, a larger network may not necessarily represent a better network. A smaller, more focused manageable network of trusted individuals could also allow the CEO obtain high quality information.[3]

Therefore, the relation between CEO network size and management forecast accuracy is an empirical issue that we investigate in this study. We test our hypothesis on a sample of 19,636 quarterly management forecasts issued from 2001-2013 and find a significant negative relation between the CEO's network size and absolute forecast error. This evidence suggests that a broader network allows the CEO to obtain information from external sources incremental to the firm's internal information system that improves management's ability to anticipate future economic

[1] Appendix A provides additional detail regarding the BoardEx database and a specific example of the composition of a CEO network.

[2] Ke, Li, Ling, and Zhang (2018) provide evidence that social connections among executives improve information exchanges within the executive team.

[3] There is also evidence that a broader network increases CEO entrenchment and power (Fracassi and Tate 2012, and El-Khatib, Fogel, and Jandik 2015). If stronger corporate governance leads to higher quality disclosure and more accurate forecasts (Karamanou and Vafeas 2005, Ajinkya, Bhojraj, and Sengupta 2005, and Hui and Matsunaga 2015), then a larger network could lead to less accurate forecasts by increasing the CEO's power within the corporate governance system.

performance.[4] Our finding is robust to a series of alternative specifications including using CEO fixed and random effects, and controlling for CEO ability for the subset of firms for which the data are available (Demerijian, Lev, and McVay 2012).

We next investigate the types of network contacts that are most useful in reducing forecast error. Specifically, we identify network contacts whose primary employer is in the same industry as the CEO's firm and contacts that are classified as an insider (executive or senior manager) for their employer firm (Engelberg et al. 2013). We find that network contacts with individuals within the same industry and contacts with individuals classified as insiders have a stronger relation with forecast error than contacts with individuals from other industries or outside directors. This suggests that an individual affiliated with a firm in the same industry, or classified as an insider with their firm, is more likely to provide information that can be useful for forecasting future earnings (Engelberg et al. 2013).

Finally we investigate conditions under which external information is most likely to be useful in improving earnings expectations. First, we find that network contacts are more useful when the firm's earnings are more highly correlated with earnings at the industry or macro levels and less useful when the firm's earnings tend to be more idiosyncratic. This evidence suggests that network connections facilitate the transfer of industry or economy-wide information that allows the CEO to derive a more accurate expectation of future earnings. Second, we find network contacts to be most effective in reducing forecast error when there is more underlying uncertainty, as measured by analyst forecast dispersion. This result is consistent with managers using their network to resolve high degrees of uncertainty. Finally, we find the relation between network

[4] In additional tests (untabulated), we find a positive relation between CEO network size and both forecast frequency and horizon. These results support the view that the CEOs' network connections allow CEOs to keep the market abreast of fluctuations in their firms' economic factors on a timely basis.

contacts and forecast error to be strongest when industries are most competitive. This is consistent with CEOs obtaining external information when their firm's performance is most likely to be affected by the performance of competitor firms.

In summary, we find that larger CEO networks are associated with lower management forecast errors. This supports the view that network contacts facilitate the transfer of economic information from external sources that allows CEOs to derive more accurate expectations of future earnings. In addition, we find evidence that contacts within the industry and from insiders allow the CEO to better forecast their firm's future performance. Finally, we find that such information is most useful when earnings are more highly correlated with the industry and macro economy, uncertainty is high, or competition is high. Our results are robust to using firm CEO fixed-effects, random effects and controlling for CEO ability.

The conclusions from our study are consistent with and add further support for the findings reported by Schabus (2018) who find that board centrality improves management forecast accuracy. Similar to Schabus (2018) our findings suggest that external information sources can improve management's projections of the firm's financial performance. Our paper expands on that finding by providing evidence that the individual CEO can use external information from his/her personal contacts to improve their earnings projections and by providing evidence regarding the types of contacts and circumstances under which the contacts are most useful.[5]

More broadly our study contributes to the general literature on voluntary disclosure and management forecasts by showing that the extent of the individual's network connections is one of the individual specific factors, documented by Bamber, Jiang, and Wang (2010) and Brochet,

[5] As discussed below, we focus on the CEO position, as opposed to the board. In addition, the measure of centrality weights contacts by their "closeness" to the firm, where we weight each relationship equally. In untabulated tests we include a control for board centrality and find that our results are qualitatively similar.

Faurel, and McVay (2011), that influences the CEO's voluntary disclosure effectiveness. Our findings also extend the findings in Baik et al. (2011) who show that CEO's of higher ability have greater forecast accuracy. Our findings suggest that an extensive network allows CEOs that have lower ability scores to use the information derived from their contacts to improve their forecast accuracy.

Our study also contributes to the burgeoning literature on the impact of CEO networks on firm value. Studies document evidence of a potentially negative effect in that CEO's with more network connections are more entrenched (Hwang and Kim 2009, Fracassi and Tate 2012, and El-Khatib et al. 2015). The literature has also documented negative effects from relationships between an acquirer and target (Ishii and Xuan 2014), customer and supplier (Chen, Levy, Martin, and Shalev 2014), the audit committee and the firm's auditor (He, Pittman, and Wu 2014), and the connectedness of the firm's audit committee and financial reporting quality (Intintoli, Kahle, and Zhao 2018). In contrast, Cai and Sevilir (2012) present evidence that relationships between the acquirer and target are associated with higher returns from acquisitions. Engleberg, Gao, and Parsons (2012) also show that relationships between management and lenders lower borrowing costs, and Brown and Drake (2014) document evidence that boards that have ties to low-tax firms also pay lower tax rates. Similarly, Chao, Kubick, Miletkov, and Wintoki (2017) provide evidence that directors connected to firms domiciled in tax havens pay lower tax rates. Our evidence suggests that the CEO's network connections can also have a positive impact by providing management with economic information from external sources that allows them to generate more accurate expectations of future financial performance.

II. Literature Review and Hypothesis Development

Prior literature suggests that personal connections and relationships can enhance economic productivity by facilitating the transfer of information between economic agents. Jaffe et al. (1993) show that patent citations tend to be related to the geographic proximity of the original patent filing, which suggests that a greater degree of geographic concentration enhances knowledge spillover (Glaeser, Kallal, Sheinkman, and Shleifer 1992). Cohen et al. (2008) and Cohen et al. (2010) present evidence that common educational ties between corporate management and mutual fund managers and sell-side analysts, respectively, enhance the transmission of firm-specific financial information. There is also evidence that individuals who have relationships with managers or directors of different firms tend to follow common policies. For example, board interlocks are related to option backdating (Bizjak, Lemmon, and Whitby 2009), earnings management (Chiu, Teoh, and Tian 2013), acquisition activity (Haunschild 1993), and private equity transactions (Stuart and Yim 2010). Similarly, Brown and Drake (2014) find that firms with a greater extent of ties with boards of low tax firms tend to have low tax rates themselves.

One implication of this research is that CEOs who have a larger network of professional, educational, or social contacts with other executives and directors have access to a greater pool of information. Such individuals could use the information to improve their understanding of the economic environment faced by their firm and better map how the firm's cost structure and product markets are going to be affected by anticipated changes to the economic environment. Individual economic agents are likely to have idiosyncratic information sets and beliefs regarding future economic activity. The larger the network, the broader the range of sources and the greater the impact of aggregation in reducing the noise associated with the individual, idiosyncratic perspectives of any single source. In addition, a larger network is likely to increase the likelihood

that the CEO will have a high quality source that provides useful information that would allow the CEO to improve the accuracy of their earnings forecasts.[6]

However, it is not clear that a broader set of contacts will improve the quality of the CEO's information. CEOs have access to internally generated information that they can use to form their expectations. Thus, the information gained from network contacts may be subsumed by the CEO's internal information for forming earnings expectations. Prior studies have generally focused on information transferred from insiders to analysts and traders, indicating that the managers' information set is superior to that possessed by outside investors. In addition, it isn't clear that a broader network provides more information than a smaller, more focused network. In a smaller network, the CEO may have stronger relationships and more active communication with those selected individuals in their network.

A larger network could also impair forecast accuracy by increasing the CEO's power within the firm thereby strengthening entrenchment and reducing management's incentives to provide accurate forecasts. El-Khatib et al. (2015) develop an aggregate measure of the CEO network, referred to as "network centrality" and find that it is related to poor merger performance. This is consistent with the findings of Ishii and Xuan (2014) who find that acquirer/target social ties are associated with poor acquisition decisions. Fracassi and Tate (2012) find that CEO/Board network ties are associated with lower firm value and Hwang and Kim (2009) find that social ties between the CEO and Board impair the independence and effectiveness of the board. Prior research also provides evidence that stronger corporate governance encourages managers to increase forecast accuracy (Ajinkya et al. 2005).

[6] Because communications between the CEO and network contacts are private and often informal, public disclosures providing direct, if anecdotal, evidence of specific examples of information transfer are not available. Therefore, following the current literature, we base our inferences on broad, indirect measures of the CEO's network.

Most relevant to our study, Schabus (2018) finds that board centrality is positively related to forecast accuracy. Schabus' (2018) results suggest that interlocked boards enhance the transmission of economic information to management that allows them to improve their forecast accuracy. While Schabus considers the board of directors, and connections with between firms, we focus on the individual officer generally held responsible for the accuracy of the forecast, the CEO, and the number of personal contacts for the individual. In addition to providing an interesting and intuitive measure of the CEO's network, the use of the number of contacts as our variable allows us to investigate the types of contacts that are most valuable in providing economic information that the CEO can use to reduce their forecast error.

Although other officers, such as the CFO, have input in forming the earnings forecast we focus on the CEO because that individual is the firm's primary representative interacting with external parties and is most likely to sit on outside boards and discuss economic affairs with top executive officers and directors of other firms. In addition, there is empirical evidence that the CEO is held responsible for setting the firm's disclosure policies and earnings forecasts. Lee, Matsunaga and Park (2012) find evidence that CEO turnover following poor performance is positively related to managerial forecast error. Brochet et al. (2011) provide evidence that CEO turnover influences the firm's disclosure policies, and Hui and Matsunaga (2015) find a positive relation between forecast accuracy and CEO pay.[7]

[7] Brochet et al. (2011) and Hui and Matsunaga (2015) provide evidence that the CFO is also involved in setting the firm's earnings forecast. While the CFO's network could also be relevant, consistent with prior literature, we form our network variable using the BoardEx Director database. As CFOs are less likely to serve as directors, they are under represented in the database. In our sample approximately 10 percent of CFOs have networks from director positions. We therefore focus on the CEO network and leave the network effects associated with other officers to future research.

Based on the above discussions regarding the effect of CEO networks on forecast accuracy, we posit the following hypotheses:

H1: The extent of a CEO's network is negatively related to absolute managerial forecast error.

While the foregoing hypothesis treats each network connection equally, our next set of hypotheses investigates the types of contacts that are most likely to provide useful information. First, we expect contacts with individuals who work in the same industry to have a greater degree of knowledge about the competitive environment of the industry (threats from entrants or potential substitute products), technological innovations in the industry, costs of complying with industry regulations, etc., that could impact the firm's future earnings. Second, an individual who serves as an insider, i.e., an executive or senior manager, for their employer firm is likely to have more information regarding their firm and its competitive environment than a non-insider and an individual affiliated with a firm in the same industry is likely to have more relevant information than an individual affiliated with a firm in a different industry (Engelberg et al. 2013).

While individuals affiliated with the same industry or holding insider positions are likely to possess more useful information, it is not clear that they would be willing to share information with a rival firm. In addition, individuals who are not insiders or from other industries may be able to provide a broader, more global perspective and information that is less likely to overlap with the information the CEO obtains from its internal information system. We therefore state the following set of hypotheses in null form:

H2A: CEO contacts with individuals employed in the same industry have the same relation with absolute managerial forecast error as contacts with individuals employed by firms in different industries.

H2B: CEO contacts with insiders have the same relation with absolute managerial forecast error as contacts with outsiders.

Our final set of hypotheses investigates the conditions under which external information sources would be most valuable. First, we expect external information to be most useful when a firm's earnings are more associated with industry and economy wide earnings. In contrast, when earnings are more idiosyncratic, the CEO is likely to rely more heavily on their internal information system. Second, we expect external information to be most valuable when the underlying uncertainty regarding earnings is greater. For example, a high level of disagreement between analysts with regard to future earnings is likely to indicate the firm's sensitivity to volatile underlying economic conditions. In such a case, a CEO is more likely to seek out and rely on external information sources to form their earnings expectation, Finally, we expect external information to be most valuable when the firm operates in a more competitive industry. In a competitive industry the firm's financial performance is more highly tied to the actions of other firms in the industry. In such cases, information external information regarding the plans and outlook of competitor firms would be most useful in assessing the CEO's firm's financial performance. This leads to our next set of hypotheses:

H3A: The relation between the size of the CEO's network and absolute managerial forecast error is stronger when the firm's earnings are more highly correlated with the overall industry or overall economy.

H3B: The relation between the size of the CEO's network and absolute managerial forecast error is stronger when the underlying uncertainty regarding future earnings is greater.

H3C: The relation between the size of the CEO's network and absolute managerial forecast error is stronger when the competition in the firm's industry is stronger.

III. Empirical Design and Results

Sample and Key Variable Definitions

Our sample consists of 19,636 management forecasts issued from 2001 – 2013. We obtain management forecast data from FirstCall and IBES, the CEO network data from BoardEx, and firm financial data from Compustat.[8] Our analysis is conducted on a firm-quarter basis. The control variables are measured as of the beginning of the quarter in which the forecast is issued. Our dependent variable is *Forecast Error*, measured as the absolute value of forecast error deflated by price (i.e., |actual earnings less management forecast|/price), multiplied by 100.

Network Size

We derive our network size variables from the BoardEx database. The database includes biographical information on over 400,000 executives and board members. To construct their database, BoardEx collects CVs from board members of public and private firms from major countries around the world. BoardEx codes information derived from the CVs, such as the individual's employment and educational histories, to form a comprehensive database that allows them to generate a network for each individual captured in their database.[9]

We use the database to form our network variables as follows.

Network_Total	=	The log of summation of *Network_Employment, Network_Education,* and *Network_Social*
Network_Emp	=	The log of summation of the CEO's employment ties. An employment tie occurs if the CEO currently or has historically overlapped with another executive or director
Network_Edu	=	The log of summation of the CEO's educational ties. An educational tie occurs if the CEO went to the same university at the same time with another executive or director

[8] Since FirstCall coverage ends 2010, we augment FirstCall by using IBES after 2010 and adding additional forecasts from IBES before 2010.

[9] We provide additional information regarding the BoardEx database and the construction of the network variable in Appendix A. Our sample consists of CEOs of public firms that are covered by FirstCall and IBES.

Network_Soc	=	The log of summation of the CEO's social ties. A social tie occurs if the CEO participated in a same social organization (e.g., charity or recreational club) at the same time with another executive or director
Same_Industry	=	The log of summation of the CEO's employment ties to individuals who are affiliated with firms in the same 2-digit SIC
Different_Industry	=	The log of summation of the CEO's employment ties to individuals affiliated with firms that are not in the same 2-digit SIC
Insider	=	The log of summation of the CEO's employment ties with individuals who are classified as executive directors and non-board managers such as CEO, COO, CFO, President, Vice-President, or Division Manager
Outsider	=	The log of summation of the CEO's employment ties with non-executive directors who are typically classified as an independent outsider

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Insert Table 1

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Table 1 presents descriptive data regarding CEO network size. Panel A of Table 1 presents the mean value for each network variable by network size quartile, along with aggregate statistics. The mean (median) number of total network contacts is 369.2 (225). The mean (median) number of total employment contacts, educational contacts, and social contacts, is 261 (122), 101.9 (46), and 6.3 (0), respectively.[10]

To provide a sense of how individuals develop large numbers of contacts, we evaluate the number of companies each CEO has worked for by total network size quartile.[11] The description

[10] We use the framework from Engelberg et al. (2013) to classify contacts. However, we calculate network contacts directly from the BoardEx network data whereas Engelberg et al. (2013) compiled network contacts from the BoardEx director profile data. We found that many social activities from profile data do not have proper dates and social contacts that do not consider dates could over-estimate the social network. Another disadvantage is that Engelberg et al. (2013) only counts educational contacts if one graduated within a year with the same degree, which might under-estimate the educational network.

[11] We count the number of companies each CEO worked for in the past or is working for currently in any capacity (i.e. executives or managers). The number of companies is calculated using firms in the BoardEx network data (Companies that are not covered by the database are therefore not included in the network.). In calculating board membership in Panel C, we count the number of director positions each CEO served in the past or is serving currently on boards of directors excluding his/her own company.

in Panel B shows that 14.4% of the CEOs in the smallest CEO network quartile have not worked for another company in the database. This drops to 0.8% for CEOs in the highest CEO network quartile. Similarly, 61.1% of the CEOs in the lowest network size quartile have worked for three or more companies, whereas 98.1% of the CEOs in the highest network size quartile have worked for three or more companies. Thus, one way for a CEO to expand their employment network is to change firms. When an individual moves to another firm, they add the executive officers and board to their network, while retaining their contacts to the board members and executive officers of their former firm.

Panel C of Table 1 presents the proportions of board memberships by total CEO network quartile. The results are similar. About 12.3% of the CEOs in the smallest total network quartile have served on two or more boards excluding their own companies. On the other hand, in the highest network quartile 54.8% serve on two or more boards. Thus, CEOs build employment networks by serving on boards of directors.

Finally, we examine the number of degrees held by CEOs. Panel D of Table 1 shows that 90.5% of CEOs in the lowest total network size quartile do not hold a graduate degree. That proportion declines to 48.2% for CEOs in the highest total network size quartile. This suggests that CEOs can expand their educational network by obtaining advanced degrees, where they are likely to overlap with other executives and board members.

Note that our theory does not imply that CEOs interact with all of the individuals in their network. Instead, individuals who have a larger network are more likely to have access to key informed individuals who can provide valuable input into the CEO's expectations model. In addition, individuals with a broader network are more likely to have access to multiple sources

and perspectives that they can then aggregate to reduce idiosyncratic noise and thus provide a more precise estimate of future economic performance.

Other Variables

Table 2 presents descriptive statistics for the other variables used in our analysis. We provide a detailed description of each variable in Appendix B. Panel A of Table 2 presents the aggregate statistics for the full sample and Panel B of Table 2 provides the mean values for each total network size quartile. Panel A of Table 2 shows that the mean absolute forecast error is 0.36% of the price per share, the mean CEO tenure approximately five years and the mean CEO age is approximately 53.9 year-old. When we separate the data by CEO network size quartile we find that forecast error steadily declines with network size quartile. This is consistent with the contention that forecast error decreases with CEO network size.[12]

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Insert Table 2

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We present the pairwise correlations between key variables in Table 3.[13] Consistent with the contention that CEOs use information gained from networks to develop more accurate estimates of future earnings, each of the network variables, is significantly negatively associated with the absolute management forecast error. The negative correlation between total network size and CEO tenure is consistent with individuals generating more network connections if they work for multiple firms. We also find that CEOs with larger networks tend to work for larger firms, with

[12] In our reported tests we control for size by taking the log. Because the log-linear functional form may not be appropriate, in unreported tests we use different functional forms, such as including a quadratic size term, and using size quartile indicator variables. The results are qualitatively similar.

[13] For brevity we report the correlations for the key test variables and suppress the correlations between the control variables. The remaining correlations are available from the authors upon request.

a greater degree of growth opportunities, a greater analyst following, and a greater degree of institutional ownership.

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Insert Table 3

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Test of the Relation between CEO Network Size and Forecast Accuracy

Our first hypothesis (H1) investigates the relation between total network size and management forecast accuracy. To test the hypothesis, we estimate the following regression.

$$\begin{aligned} \text{Forecast\_Error} = {} & \alpha_0 + \alpha_1 \text{Network\_Total} + \alpha_2 \text{Tenure} + \alpha_3 \text{Age} + \alpha_4 \text{Inst\_Own} \\ & + \alpha_5 \text{Ind\_Directors} + \alpha_6 \text{Num\_Analysts} + \alpha_7 \text{Loss} + \alpha_8 \text{Increase} \\ & + \alpha_9 \text{Earn\_Volatility} + \alpha_{10} \text{Ret\_Volatility} + \alpha_{11} \text{Firm\_Size} + \alpha_{12} \text{Growth} \\ & + \alpha_{13} \text{Horizon} + e_1 \end{aligned} \quad (1)$$

The dependent variable is the absolute error of a forecast for quarterly earnings issued by a given firm.[14] If the firm issued multiple forecasts for a given quarter, we keep the first forecast.[15] The key test variable is the log of the CEO's total network. The control variables include CEO characteristics (tenure and age), firm governance characteristics (institutional ownership and independent directors), the information environment (degree of analyst coverage), earnings predictability (loss, increase, and earnings volatility), overall uncertainty in the competitive environment (return volatility, firm size and growth), and the forecast horizon.[16] If values are available on a quarterly basis, we measure the value for the beginning of the quarter in which the

[14] The results are robust even after including annual forecasts as well as quarterly forecasts.
[15] We use the first forecast because it has the longest horizon and therefore requires more forward-looking information. In an unreported test we use the latest forecast, which presumably includes the most amount of information. The results are robust to using the latest forecast.
[16] In robustness tests we replace age with time to retirement to capture effects relating to the CEO's time horizon incentives and replace increase over the prior quarter with increase over the same quarter of the prior year. The results (not reported) are qualitatively similar.

forecast is issued. We measure variables whose values are only available on an annual basis as of the year-end preceding the quarter in which the forecast is issued. The regression also includes year and firm fixed effects to reduce potential biases from correlated omitted variables such as unobserved time-invariant firm characteristics.

To investigate whether the relation differs based on the source of network contacts we separate the CEO's network into separate variables based on whether the contact comes from an employment relation (*Network_Emp*), attending a common educational institution (*Network_Edu*), or affiliations with social organizations (*Network_Soc*). We take the log of each network variable (if the number of contacts for a specific network source is zero we set the value of the log variable to zero).

We report the results in Panel A of Table 4. The first column reports the results for the test of H1. The significantly negative coefficient (-0.030; $p < 0.01$) for *Network_Total* indicates that CEOs who have larger networks are able to forecast earnings more accurately. This is consistent with a greater number of network contacts providing information regarding the competitive environment to the CEO that can be used to generate a more accurate expectation of future earnings. To assess the economic significance we find that an increase from the bottom to the top quartile of Network_Total (4.595 to 6.222) reduces the mean forecast error by 13.6%. Similarly, an increase from the bottom to the top quartile of Network_Emp reduces the mean forecast error by 16.8%.

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Insert Table 4

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The results in columns 2 – 4 of Panel A of Table 4 present the results for the individual network source variables. Following Engelberg et al. (2013), we classify connections as coming from employment, educational, or social relationships. We find the coefficient for each network variable to be significantly negative, indicating that contacts from each source, whether from an employment, education, or social relationship, provides information the CEO can use to increase the accuracy of forecasted earnings. In the final column of Panel A of Table 4, we include the log of the number of contacts from each source as a separate independent variable and find that each is significantly negative at conventional levels. The results suggest that contacts from each type of relationship are useful in providing information to improve earnings expectations.

In our main regressions we control for the CEO's tenure and age and we control for the CEO's overall ability below. However, there could still be concern that our findings are driven by another unobservable CEO characteristic. We therefore conduct two additional tests. First, we replace firm fixed effects with CEO fixed effects. This serves to control for the CEO's average network size during the sample period and allows the network size variable to pick up deviations in the CEO's network from the mean during the sample period. Second, we replace CEO fixed effects with random effects. The fixed effects assume that the CEO–specific effects are correlated with the independent variables whereas the random effects assume that the CEO–specific effects are uncorrelated with the independent variables. The results for CEO fixed effects (presented in Panel B of Table 4) and random effects (presented in Panel C of Table 4) are consistent with the main test and provide added confidence that that the observed negative relation between network size and forecast error is not driven by omitted CEO characteristics.

Tests of the Type of Employment Contact

Hypotheses H2A and H2B investigate whether the impact of network contacts on forecast error differs based on the type of contact. Hypothesis 2A examines whether the relation differs based on whether the contact works in the same industry and Hypothesis 2B examines whether it matters whether the contact is an insider for their own firm. To test for a common industry effect we define two variables. *Same_Industry* and *Different_Industry,* represent the log of the number of contacts from firms that are in the same two-digit SIC code as the forecasting firm, and from a different industry, respectively.[17] To test for an insider information effect we define variables *Insider* and *Outsider*, as the log of the number of contacts for individuals who are classified as insiders for their employer firms, i.e., executive officers and senior managers, and the log of all other employment contacts, respectively.

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Insert Table 5

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Panel A of Table 5 presents the results for the test of H2A relating to the industry of the employment contact. We find the coefficient for *Same_Industry* to be significantly negative, while the coefficient for *Different_Industry* is not significant. In addition, we find the coefficients to be significantly different ($p < 0.01$). When we include both variables in the regression, we find similar results with *Same_Industry* being significantly negatively related to forecast error, and *Different_Industry* remaining insignificant. Furthermore, we find that the coefficients are significantly different ($p < 0.01$). Overall, the results are consistent with network contacts providing industry-related information useful for forecasting future earnings.

[17] To prevent losing network contacts due to missing industry codes we assume the proportion of "same" versus "different" industry contacts is constant for contacts without an industry code. We complement this assumption by using "sector" information in the BoardEx, because all contacts have sector information. The results using sector instead of two-digit SIC are robust.

Panel B of Table 5 presents the results for the test of H2B relating to the insider status of the contact. In the separate regressions we find that the coefficient for the log of insider contacts (*Insider*) is significantly negative (-0.023; $p < 0.01$), while the log of outsider contacts (*Outsider*) is insignificant. When we include both variables in the regression, we find similar results with the coefficient of *Insider* being significantly negative, and the coefficient for *Outsider* remaining insignificant. In addition, we find the coefficients to be significantly different ($p < 0.10$). Taken together, these results suggest that the information gathered from individuals who have a more in depth knowledge of their competitive environment is more useful in reducing forecast error.

Tests of Underlying Conditions

Hypotheses 3A, 3B and 3C examine whether information from external sources is more useful under certain economic conditions. Hypothesis 3A investigates whether the impact of CEO network contacts on forecasting accuracy is greater when a firm's earnings are more closely tied to industry and economy-wide earnings and less idiosyncratic. To investigate this hypothesis we compute the Pearson correlation between the firm's return on equity and the mean return on equity for firms in the same SIC two-digit industry, or Compustat sample, over the prior sixteen quarters. We then interact the correlation with our main interest variable, *Network_Emp* to examine whether the network effect of reducing forecast error will increase as a firm's earnings are highly associated with industry and economy-wide earnings.

We report the results of systematic or idiosyncratic earnings in Table 6. The coefficients for the interactions between *Network_Emp* and both correlation measures *Ind._Earn_Corr* ($p < 0.05$) and *Mkt._ Earn_Corr* ($p < 0.01$) are significantly negative. These results support the contention that a broader set of network contacts provides the CEO with information on industry

trends and macro economy trends that allows the CEO to improve their expectation of earnings if their firm's earnings are more closely tied to overall economic performance.

Hypothesis 3B investigates whether external information sources are more important when there is a greater degree of underlying uncertainty. We use the dispersion in analyst forecast to measure the extent of underlying uncertainty and define an indicator variable equal to one if it is in the highest dispersion quintile or decile. To examine the impact of uncertainty on the value of external information we interact the indicator variable with the log of the CEO's employment network contacts. We measure analyst dispersion as the standard deviation of analyst forecasts.[18]

We present the results in Panel B of Table 6. We find significantly negative coefficients for the interaction of each dispersion indicator variable with the CEO's employment network. We also find that the magnitude of the effect and the level of significance are greater for the dispersion decile variable than the quintile indicator variable. This suggests the impact of the CEO's network contacts on forecast accuracy is most important when underlying uncertainty is especially high. In other words, CEOs can generally rely on their internal information sources to form their earnings expectations. However, when their earnings are especially sensitive to underlying economic conditions, they are more likely to reach out to, and incorporate information from, external sources to improve their earnings forecasts.

Hypothesis 3C investigates whether the impact of external information sources on forecast accuracy is greater when the firm operates in a competitive industry. To measure competition we construct a "fluidity" variable that is based on a textual analysis of the firm's business in the firm's 10-K filing (Hoberg, Phillips and Prabhala 2014). Fluidity is greater when the firm's product words

[18] We require at least 2 analysts to calculate the standard deviation and use the most recent analysts forecasts prior to the management forecast.

overlap more with the vector of product words used by rivals. A higher degree of overlap indicates a higher competitive threat from rivals. As with uncertainty, we define indicator variables that are set equal to one if the firm's industry is in the highest competition quintile, or decile, respectively.

We present the results in Panel C of Table 6. The results support the contention that external information is most valuable in reducing forecast error when competition is high. As before we find that both the magnitude of the coefficient and level of significance are higher for the decile indicator variable than the quintile variable, which is consistent with external information being most valuable when the industry competition is very high.

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Insert Table 6

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Additional Tests:

Controlling for CEO's Overall Ability

Given Baik et al.'s (2011) finding that CEO's with higher overall ability are able to forecast more accurately, we follow their procedure and use the CEO ability values from Peter Demerjian's web site to control for CEO ability on a subsample of our observations. Demerjian's procedure uses data envelope analysis to estimate the efficient frontier linking inputs to outputs and assesses the distance of each firm from the efficient frontier.[19]

[19] Additional details can be found in Demerjian et al. (2012). In their procedure, the output is sales and the inputs are cost of goods sold, sales, general and administrative expenses, property, plant and equipment, operating leases, research and development expenditures, goodwill, and other intangible assets.

Panel A of Table 7 provides data on the network size variables for CEOs with above and below median ability. Perhaps surprisingly, we find that lower ability CEOs tend to have larger networks, i.e., ability and network size are negatively correlated. Thus, it does not appear as though network size is a proxy for CEO ability in explaining management forecast error.

To formally control for the effect of CEO ability we estimate the following regression:

$$\begin{aligned} \text{Forecast\_Error} = {} & \beta_0 + \beta_1 \text{Network\_Total} + \beta_2 \text{Network\_Total*Ability} + \beta_3 \text{Ability} \\ & + \beta_4 \text{Tenure} + \beta_5 \text{Age} + \beta_6 \text{Inst\_Own} + \beta_7 \text{Ind\_Directors} \\ & + \beta_8 \text{Num\_Analysts} + \beta_9 \text{Loss} + \beta_{10} \text{Increase} + \beta_{11} \text{Earn\_Volatility} \\ & + \beta_{12} \text{Ret\_Volatility} + \beta_{13} \text{Firm\_Size} + \beta_{14} \text{Growth} + \beta_{15} \text{Horizon} + e_2 \end{aligned} \quad (2)$$

In addition to controlling for CEO ability through the Ability direct effect, the interaction term with network size allows us to examine whether there is difference in how high and low ability CEOs are able to utilize their networks to improve their forecast accuracy. A negative coefficient would support a complementary relation in that CEOs with higher ability are better able to use the information from the network to reduce forecast error. A positive coefficient would support a substitute relation in that, the information gained from outside network contacts has a smaller impact on the accuracy of the forecast for CEOs with higher overall ability.

We report the results from the estimation of regression equation (2) in Panel B of Table 7. For brevity we do not report the results for the full set of control variables. We find that the coefficients of the CEO network variables are significantly negative. This provides evidence that our prior findings are robust to controlling for CEO ability. We also find that the coefficient of each CEO network variable interacted with CEO ability is significantly positive. These results are consistent with a substitution effect whereby the information provided through the CEOs external network has a smaller effect on the accuracy of the earnings forecast if the CEO has high overall managerial ability.

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Insert Table 7

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Two-stage Instrumental Variable Approach

The extent to which a CEO's network represents a choice variable, either by the individual or the board, is not clear. The CEO's network is determined by a number of factors, some of which can be influenced by the CEO's decisions, and some that are not. For example, the individual can choose to become involved in a social organization or choose to serve as an outside board member for a public company. On the other hand, the individual may have no control over whether other graduates from their alma mater rise to become executive officers. Similarly, while the board may consider the CEO's network in appointing the CEO it is not clear whether this is a first order effect and a CEO's network is likely to change over time for reasons over which the board has no control.

The possibility that the CEO network reflects choices creates the potential for endogeneity and potential bias from correlated omitted variables. To alleviate this concern, we use an instrumental variable two-stage approach. In the first-stage we estimate a regression with the CEO's network size as the dependent variable and use the industry average CEO network size as our instrument.[20] Our choice is based on the theory that firms follow an industry norm, and interlocking practices between CEOs would give more opportunity to build networks within their industry if CEOs, in general have broader networks. On the other hand, we do not expect industry average networks to affect firm forecast accuracy. The predicted CEO network size from the first

[20] We also use the industry mean number of outside board members as both an alternative, and as an additional, instrumental variable. The theory underlying this instrument is that the greater the industry utilizes outside board members, the greater the opportunities for the CEO to generate a broader network. The results are consistent with those reported using the industry average network. Because the weak instrument test (see below) indicates that the industry average network is a stronger instrument, for brevity we do not report the results of the alternative tests.

stage becomes the regression is the test variable in the second stage. Because the test variable is determined solely by the variables identified in the first stage, it is less likely to reflect unobservable factors that are correlated with management forecast accuracy.

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Insert Table 8

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We report the findings in Table 8. Consistent with prior findings we find a significantly negative coefficient for the instrumental variable in the second stage. This result provides additional evidence that larger CEO networks facilitate the transfer of information that the individual can use to form a more accurate forecast of future earnings.

To validate our choice of the industry average network as an instrument we follow Larcker and Rusticus (2010) and conduct weak instrument identification and Hausman specification tests. The partial R^2 of the first stage regression is 7.8% and partial F is 1670. The Cragg-Donald Wald F statistic is 1585, which exceeds the 10% (25%) critical value of 16.4 (5.5) based on Stock and Yogo (2005). Overall, the results suggest that the instrument passes the weak instrument tests by explaining a significant amount of the CEO's network size. The Hausman test yields a Wu-Hausman F value of 15.7 ($p < 0.01$). This test supports the contention that the instrumental variable improves the specification over the OLS estimation.[21]

[21] We do not conduct an over-identification test (Larcker and Rusticus 2010) because we only employ one instrumental variable.

Non-Linear Threshold Approach

We further explore the relation between the network size and forecast accuracy by examining whether there is a threshold effect. Specifically, while the prior finding suggests that there is a negative effect between the number of the CEO's network contacts and forecast error it isn't clear whether the relation increases monotonically throughout the distribution, i.e., whether the incremental effect of an additional contact is constant. To investigate this issue we separate the number of network contacts into quartiles and define indicator variables set equal to one for observations in each quartile of the distribution. We present the results in Table 9. We find a significantly negative coefficient for the highest quartile (-0.013; $p < 0.01$). This is consistent with a threshold effect whereby the CEO needs to have a fairly large network in order to obtain information that is useful in setting expectations for future earnings. This suggests that CEOs who have broad networks are able to aggregate information from a variety of sources to develop a more accurate picture of the economic environment faced by the firm.

IV. Summary and Conclusion

In this study we document evidence that large CEO networks are associated with lower management forecast error and that this result holds for all network sources (employment, education, and social). Our findings also indicate that contacts from the same industry and from individuals who serve as insiders for their own firm have the greatest impact on forecast error, which suggests that the most valuable information provides managers with a more accurate view of the industry's competitive environment. In addition, we find that the negative relation between CEO network size and management forecast error is strongest when earnings are more systematic and less idiosyncratic, when underlying uncertainty is high, or industry competition is high. These

results provide evidence that the external information provides CEOs with better forecasts of industry, or overall economic trends.

Overall, our findings provide insight into the manner in which external information sources complement a firm's internal information system to develop accurate forecasts of future earnings. Specifically, our evidence suggests that having a large number of contacts with individuals from the same industry, or with insider knowledge, provides CEOs with information about industry and macro-economic trends that allows CEOs, particularly those with lower ability, to improve their earnings forecasts.

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APPENDIX A
Description of the BoardEx Database

To construct their database, BoardEx begins with all publicly listed companies and then adds in the most notable and most requested private companies. The database includes over 18,000 companies. For each company they obtain the full list of board members, senior managers and disclosed earners. They then use C.V.'s to develop each individual's employment history, educational background, and affiliation with foundations, charitable organizations, etc.

Although the BoardEx database includes a "Network Size" variable, we calculate the network size for each CEO from their network database. This procedure allows us to calculate the sub-category network size variables and allows the network size to vary over time. Although BoardEx has a senior manager database, we restrict our analysis to the director database because most CEOs are executive directors as opposed to senior managers.

A CEO's network includes individuals who are not affiliated with the CEO's firm, outside directors for the CEO's firm, and executives and managers of the CEO's firm who serve as outside directors for other firms. Because all of these contacts represent access to information from external sources, we include all of the contacts in our measure. As a sensitivity test we exclude contacts with individuals with ties to the CEO's own firm and the results are qualitatively similar.

As an example, consider former Quantum CEO Rick Belluzzo. In our study his network size is 978 (all employment related). In addition to being CEO of Quantum, Mr. Belluzzo has served on the board of Imation, PMC-Sierra, JDS Uniphase, Silicon Graphics, Proxima, and Specialty Laboratories. Prior to becoming CEO of Quantum, Mr. Belluzzo worked for Microsoft and Hewlett-Packard. His network consists of external network of 948 contacts from the current and past director positions and individuals with whom he worked with in his previous positions with other firms and internal network of 30 contacts from Quantum.

We use the following diagram to illustrate the construction of the employment network variable. As you can see, Mr. Belluzzo's network consists of all of the executive officers and directors for Quantum during Mr. Belluzzo's tenure as CEO. In addition, Mr. Belluzzo served as an outside board member for JDS Uniphase. His network therefore includes all of the executive officers and directors, including the CEO, that were present during his tenure as an outside board member. Finally, Mr. Belluzzo worked for Microsoft from 1999 – 2002 as a group V.P. and President. Therefore, his network includes Microsoft's executive officers and directors for that time period.

(Continued on next page)

APPENDIX A (Continued)

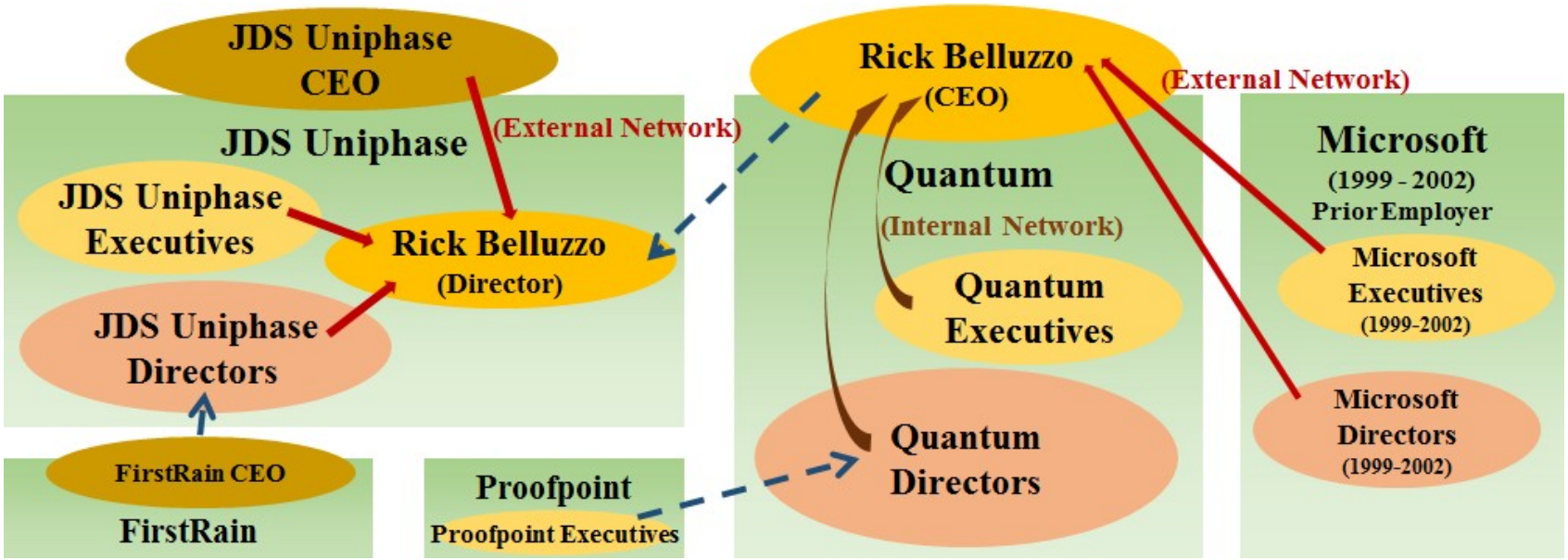

Diagram of CEO Network Connections

APPENDIX B
Variable Definitions

Variable		Definitions	Data Source
Forecast Error	=	The absolute value of forecast error deflated by price (i.e., |actual earnings less management forecast| / price), multiplied by 100	FirstCall
Network Variables			
Network_Total	=	The log of summation of *Network_Employment, Network_Education,* and *Network_Social*	BoardEx
Network_Emp	=	The log of summation of the CEO's employment ties. An employment tie occurs if the CEO currently or has historically overlapped with another executive or director	BoardEx
Network_Edu	=	The log of summation of the CEO's educational ties. An educational tie occurs if the CEO went to the same university at the same time with another executive or director	BoardEx
Network_Soc	=	The log of summation of the CEO's social ties. A social tie occurs if the CEO participated in a same organization (e.g., charity or recreational club) at the same time with another executive or director	BoardEx
Same_Industry	=	The log of summation of the CEO's employment ties to individuals who are affiliated with firms in the same 2-digit SIC	BoardEx, Compustat
Different_Industry	=	The log of summation of the CEO's employment ties to individuals affiliated with firms that are not in the same 2-digit SIC	BoardEx, Compustat
Insider	=	The log of summation of the CEO's employment ties with individuals who are classified as executive directors and non-board managers such as CEO, COO, CFO, President, Vice-President, or Division Manager	BoardEx
Outsider	=	The log of summation of the CEO's employment ties with non-executive directors who are typically classified as an independent outsider	BoardEx
Network_Quartile2	=	An indicator variable that equals 1 if the CEO's network is in the second quartile of the distribution, and 0 otherwise	BoardEx
Network_Quartile3	=	An indicator variable that equals 1 if the CEO's network is in the third quartile of the distribution, and 0 otherwise	BoardEx
Network_Quartile4	=	An indicator variable that equals 1 if the CEO's network is in the fourth quartile of the distribution, and 0 otherwise	BoardEx
Conditioning Variables			
Ability	=	The DEA score based on the measure developed in Demerjian et al. (2012b)	Demerjian's web site
Ind._Earn_Corr	=	Correlation of ROE changes between the firm and industry (at SIC2) level.	Compustat
Mkt._Earn_Corr	=	Correlation of ROE changes between the firm and market level.	Compustat

(Continued on next page)

APPENDIX B (Continued)

Variable		Definitions	Data Source
Conditioning Variables (continued)			
Uncertainty	=	Uncertainty is measured as the standard deviation in analyst forecasts. We define an indicator variable equal to one if it is in the highest dispersion quintile or decile.	IBES
Competition	=	Fluidity based on the overlap of product words in the firm's business description from their 10-K filing described in detail in Hoberg, Phillips, and Prabhala (2014). We define an indicator variable equal to one if it is in the highest dispersion quintile or decile.	Hoberg and Phillips' Data Library
Control Variables			
Tenure	=	The number of years that the CEO has held the position of chief executive officer	BoardEx
Age	=	The age of the CEO from the BoardEx database	BoardEx
Inst_Own	=	The percentage of institutional ownership at the beginning of the quarter t	Thompson & Reuters
Ind_Directors	=	The number of independent directors scaled by the total number of directors in the board of the firm	BoardEx
#Analyst	=	The number of analysts following the firm in the current quarter	FirstCall
Loss	=	1 if the firm's current earnings is negative, and 0 otherwise	Compustat
Increase	=	1 if the firm's current earnings increased compared to the previous quarters' earnings, and 0 otherwise	Compustat
Earn_Volatility	=	The standard deviation of quarterly earnings scaled by the total assets over the past 4 years	Compustat
Ret_Volatility	=	The standard deviation of daily raw stock returns over the last three years	CRSP
Firm Size	=	Total assets in the beginning of the quarter t	Compustat
Growth	=	The market-to-book ratio measured by the market value of common equity scaled by book value of common equity in the beginning of the quarter.	Compustat
Horizon	=	The number of days between the forecast date and the earnings announcement date	FirstCall

TABLE 1
Network Size

Panel A: Mean Values for Each Network Size Quartile and Aggregate Statistics

Variable	Low	Q2	Q3	High	Mean	Median	Std. Dev.
Network_Total	53.22	156.02	347.22	921.62	369.2	225.0	399.0
Network_Emp	44.01	99.54	219.09	682.09	261.0	122.0	334.4
Network_Edu	8.86	55.32	124.62	219.23	101.9	46.0	141.1
Network_Soc	0.35	1.16	3.51	20.30	6.3	0.0	40.2
Same_Industry	38.80	75.71	144.09	444.70	147.5	62.0	227.0
Different_Industry	3.34	17.82	56.40	247.44	64.5	0.0	197.2
Insiders	32.59	78.96	189.64	639.79	235.1	97.0	322.7
Outsiders	11.42	20.58	29.45	42.30	25.9	19.0	22.4
Industry Leaders	27.83	81.50	187.25	587.68	221.3	101.0	300.7
Industry Non-leaders	16.12	18.15	31.95	56.80	30.8	0.0	80.4

Panel B: Proportional Number of Firms the CEO Has Worked for by Network Size Quartile

	Low	Q2	Q3	High
1 firm	14.4%	0.7%	0.1%	0.8%
2 firms	24.5%	9.4%	3.2%	1.1%
3 firms or more	61.1%	89.8%	96.8%	98.1%
Total	100%	100%	100%	100%

Panel C: Proportion of Board Memberships by Network Size Quartile

	Low	Q2	Q3	High
No position	55.2%	38.1%	30.2%	18.3%
1 position	32.5%	29.4%	26.0%	26.9%
2 positions or more	12.3%	32.5%	43.8%	54.8%
Total	100%	100%	100%	100%

Panel D: Proportion of Graduate Degrees Held by CEO by Network Size Quartile

Variable	Low	Q2	Q3	High
No graduate degree	90.5%	74.6%	58.8%	48.2%
1 graduate degree	8.4%	23.3%	35.6%	38.9%
2 graduate degrees or more	1.1%	2.1%	5.6%	12.9%
Total	100%	100%	100%	100%

This table reports the descriptive statistics of main interest network variables. Panel A presents the mean network contacts by network size quartile as well as basic descriptive statistics. Panel B, C, and D provides proportion of number of firms, board memberships, and graduate degrees by network size quartile. In Panel B, we count the number of companies each CEO worked for in the past or is working for currently in any capacity (i.e. executives or managers). The number of companies is calculated using firms in the BoardEx network data. In calculating board membership in Panel C, we count the number of director positions each CEO served in the past or is serving currently on boards of directors. A description of each variable can be found in Appendix B.

TABLE 2
Descriptive Statistics for Regression Variables

Panel A: Complete Sample

Variable	N	Mean	Std. Dev.	Q1	Median	Q3
Forecast Error	19,636	0.361	0.750	0.049	0.136	0.346
Tenure	19,636	4.926	4.650	1.500	3.500	6.900
Age	19,636	53.878	7.364	49.000	54.000	59.000
Inst_Own	19,636	0.614	0.326	0.447	0.710	0.852
Ind_Directors	19,636	0.743	0.134	0.667	0.750	0.857
#Analyst	19,636	9.332	6.427	5.000	8.000	13.000
Loss	19,636	0.182	0.386	0.000	0.000	0.000
Increase	19,636	0.546	0.498	0.000	1.000	1.000
Earn_Volatility	19,636	0.022	0.027	0.007	0.013	0.027
Ret_Volatility	19,636	0.031	0.012	0.022	0.029	0.037
Firm Size	19,636	6,045	40,415	355	1,000	3,362
Growth	19,636	3.258	2.875	1.554	2.399	3.817
Horizon	19,636	82.894	25.390	83.000	91.000	94.000

Panel B: Mean Values for Each Network Size Quartile

Variable	Low	Q2	Q3	High	High - Low
Forecast Error	0.416	0.360	0.386	0.280	-0.136***
Tenure	5.264	4.696	4.925	4.817	-0.446***
Age	54.755	53.703	53.928	53.121	-1.634***
Inst_Own	0.593	0.624	0.620	0.620	0.028***
Ind_Directors	0.699	0.739	0.756	0.778	0.079***
#Analyst	7.189	8.883	9.604	11.662	4.473***
Loss	0.185	0.173	0.205	0.165	-0.021***
Increase	0.531	0.546	0.546	0.560	0.030***
Earn_Volatility	0.021	0.022	0.024	0.021	0.000
Ret_Volatility	0.033	0.031	0.031	0.029	-0.003***
Firm Size	1,268	2,894	5,374	14,662	13,394***
Growth	2.826	3.104	3.530	3.576	0.750***
Horizon	82.244	82.846	81.587	84.903	2.659***

This table reports the correlations between the variables used in the regression analyses. A description of each variable can be found in the Appendix B.

TABLE 3
Key Pairwise Correlations

	Forecast_ Error	*Network_ Total*	*Network_ Emp*	*Network_ Edu*	*Network_ Soc*
Forecast Error	1.000				
Network_Total	-0.056	1.000			
	<.0001				
Network_Emp	-0.049	0.875	1.000		
	<.0001	<.0001			
Network_Edu	-0.048	0.627	0.291	1.000	
	<.0001	<.0001	<.0001		
Network_Soc	-0.032	0.257	0.223	0.114	1.000
	<.0001	<.0001	<.0001	<.0001	
Tenure	-0.022	-0.035	-0.072	0.043	0.041
	0.002	<.0001	<.0001	<.0001	<.0001
Age	-0.001	-0.061	-0.015	-0.086	0.062
	0.916	<.0001	0.033	<.0001	<.0001
Inst_Own	-0.069	0.033	0.032	0.027	0.001
	<.0001	<.0001	<.0001	0.000	0.905
Ind_Directors	-0.004	0.239	0.247	0.128	0.104
	0.605	<.0001	<.0001	<.0001	<.0001
#Analyst	-0.160	0.272	0.303	0.091	0.122
	<.0001	<.0001	<.0001	<.0001	<.0001
Loss	0.229	-0.012	-0.004	-0.019	-0.066
	<.0001	0.106	0.533	0.007	<.0001
Increase	0.015	0.020	0.017	0.008	-0.012
	0.031	0.005	0.015	0.288	0.096
Earn_Volatility	0.122	0.001	-0.010	-0.003	-0.088
	<.0001	0.841	0.144	0.710	<.0001
Ret_Volatility	0.141	-0.123	-0.145	-0.054	-0.139
	<.0001	<.0001	<.0001	<.0001	<.0001
Firm Size	-0.120	0.366	0.408	0.162	0.287
	<.0001	<.0001	<.0001	<.0001	<.0001
Growth	-0.124	0.102	0.095	0.049	0.023
	<.0001	<.0001	<.0001	<.0001	0.002
Horizon	0.086	0.036	0.039	0.007	-0.016
	<.0001	<.0001	<.0001	0.298	0.022

This table reports the correlations between the variables used in the regression analyses. A description of each variable can be found in the Appendix B. For brevity, we suppress the correlations between the control variables and focus on the correlations for the dependent variable and the key test variables of interest. The additional correlations are available from the authors upon request.

TABLE 4
Network Size and Management Forecast Error

Panel A: Total Network Size by Source of the Network Contact

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*	(3) *Forecast Error*	(4) *Forecast Error*	(5) *Forecast Error*
Network_Total	**-0.030*** **				
	(0.003)				
Network_Emp		**-0.034*** **			**-0.027*** **
		(0.001)			**(0.007)**
Network_Edu			**-0.015*** **		**-0.012*** **
			(0.001)		**(0.007)**
Network_Soc				**-0.027*** **	**-0.024*** **
				(0.001)	**(0.002)**
Tenure	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
Age	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Inst_Own	-0.065***	-0.065***	-0.064***	-0.065***	-0.066***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ind_Directors	-0.078	-0.085	-0.075	-0.092	-0.083
	(0.295)	(0.255)	(0.317)	(0.218)	(0.268)
#Analyst	-0.113***	-0.113***	-0.112***	-0.113***	-0.112***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Loss	0.273***	0.273***	0.272***	0.272***	0.273***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Increase	0.075***	0.075***	0.074***	0.074***	0.074***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Earn_Volatility	1.117***	1.102***	1.117***	1.078***	1.103***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ret_Volatility	1.928**	1.952**	1.901**	1.920**	2.037**
	(0.021)	(0.020)	(0.023)	(0.022)	(0.015)
Firm Size	-0.182***	-0.180***	-0.183***	-0.185***	-0.180***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Growth	-0.038***	-0.038***	-0.038***	-0.038***	-0.038***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Horizon	0.004***	0.004***	0.004***	0.004***	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	19,636	19,636	19,636	19,636	19,636
R-squared	0.425	0.425	0.425	0.425	0.425
Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

p-value in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

(Continued on Next Page)

TABLE 4 (Continued)

Panel B: CEO Fixed Effects

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*	(3) *Forecast Error*	(4) *Forecast Error*
Network_Total	**-0.079****			
	(0.012)			
Network_Emp		**-0.077*****		
		(0.006)		
Network_Edu			**-0.084*****	
			(0.000)	
Network_Soc				**-0.048*****
				(0.000)
Tenure	-0.008**	-0.008**	-0.007**	-0.007**
	(0.012)	(0.011)	(0.017)	(0.016)
Age	0.012	0.013	0.014	0.012
	(0.506)	(0.464)	(0.421)	(0.490)
Inst_Own	-0.056***	-0.056***	-0.056***	-0.057***
	(0.001)	(0.001)	(0.001)	(0.001)
Ind_Directors	-0.078	-0.00083	-0.088	-0.091
	(0.372)	(0.343)	(0.314)	(0.299)
#Analyst	-0.093***	-0.093***	-0.090***	-0.093***
	(0.000)	(0.000)	(0.000)	(0.000)
Loss	0.248***	0.248***	0.248***	0.249***
	(0.000)	(0.000)	(0.000)	(0.000)
Increase	0.072***	0.072***	0.072***	0.072***
	(0.000)	(0.000)	(0.000)	(0.000)
Earn_Volatility	1.076***	1.094***	1.013***	1.042***
	(0.001)	(0.001)	(0.002)	(0.001)
Ret_Volatility	1.246	1.293	1.278	1.284
	(0.201)	(0.185)	(0.189)	(0.187)
Firm Size	-0.179***	-0.176***	-0.179***	-0.185***
	(0.000)	(0.000)	(0.000)	(0.000)
Growth	-0.041***	-0.041***	-0.041***	-0.041***
	(0.000)	(0.000)	(0.000)	(0.000)
Horizon	0.003***	0.003***	0.003***	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	19,636	19,636	19,636	19,636
R-squared	0.477	0.477	0.477	0.477
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

p-value in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

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TABLE 4 (Continued)

Panel C: CEO Random Effects

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*	(3) *Forecast Error*	(4) *Forecast Error*
Network_Total	**-0.020****			
	(0.018)			
Network_Emp		**-0.021****		
		(0.014)		
Network_Edu			**-0.013*****	
			(0.001)	
Network_Soc				**-0.017****
				(0.020)
Tenure	-0.007***	-0.007***	-0.006***	-0.006***
	(0.000)	(0.000)	(0.000)	(0.000)
Age	0.005***	0.005***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)
Inst_Own	-0.070***	-0.071***	-0.069***	-0.070***
	(0.000)	(0.000)	(0.000)	(0.000)
Ind_Directors	-0.002	-0.005	-0.001	-0.014
	(0.973)	(0.936)	(0.993)	(0.825)
#Analyst	-0.138***	-0.138***	-0.138***	-0.139***
	(0.000)	(0.000)	(0.000)	(0.000)
Loss	0.290***	0.290***	0.289***	0.289***
	(0.000)	(0.000)	(0.000)	(0.000)
Increase	0.080***	0.080***	0.079***	0.079***
	(0.000)	(0.000)	(0.000)	(0.000)
Earn_Volatility	1.522***	1.512***	1.522***	1.494***
	(0.000)	(0.000)	(0.000)	(0.000)
Ret_Volatility	2.411***	2.428***	2.375***	2.365***
	(0.002)	(0.002)	(0.002)	(0.002)
Firm Size	-0.025***	-0.025**	-0.027***	-0.028***
	(0.008)	(0.011)	(0.005)	(0.003)
Growth	-0.032***	-0.032***	-0.032***	-0.032***
	(0.000)	(0.000)	(0.000)	(0.000)
Horizon	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	19,636	19,636	19,636	19,636
R-squared	0.102	0.101	0.102	0.101
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

This table reports the results for an OLS regression examining the effect of network size on absolute forecast error. Descriptions of each variable can be found in the Appendix B. The sample includes 19,636 quarterly management forecasts. (*** Significant at two-tailed $p < 0.01$; ** Significant at two-tailed $p < 0.05$; * Significant at two-tailed $p < 0.10$.) Our main result is robust under CEO fixed effects and random fixed effects.

TABLE 5
The Source of Knowledge Spillover effect of CEO Network on Management Forecast

Panel A: The Effect of Industry Knowledge on Forecast Errors

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*	(3) *Forecast Error*
Same_Industry	**-0.063*** **		**-0.065*** **
	(0.000)		**(0.000)**
Different_Industry		-0.003	-0.005
		(0.630)	(0.333)
Network_Edu	-0.029***	-0.032***	-0.028***
	(0.000)	(0.000)	(0.000)
Network_Soc	-0.070***	-0.072***	-0.070***
	(0.000)	(0.000)	(0.000)
Tenure	-0.003	-0.003	-0.003
	(0.284)	(0.293)	(0.317)
Age	0.005***	0.006***	0.005***
	(0.003)	(0.002)	(0.003)
Inst_Own	-0.070***	-0.068***	-0.071***
	(0.003)	(0.004)	(0.003)
Ind_Directors	-0.173*	-0.147	-0.167
	(0.089)	(0.149)	(0.101)
#Analyst	-0.127***	-0.126***	-0.126***
	(0.000)	(0.000)	(0.000)
Loss	0.319***	0.317***	0.319***
	(0.000)	(0.000)	(0.000)
Increase	0.074***	0.074***	0.074***
	(0.000)	(0.000)	(0.000)
Earn_Volatility	0.170	0.191	0.182
	(0.675)	(0.637)	(0.653)
Ret_Volatility	4.316***	4.435***	4.330***
	(0.000)	(0.000)	(0.000)
Firm Size	-0.243***	-0.249***	-0.243***
	(0.000)	(0.000)	(0.000)
Growth	-0.047***	-0.048***	-0.047***
	(0.000)	(0.000)	(0.000)
Horizon	0.004***	0.004***	0.004***
	(0.000)	(0.000)	(0.000)
Observations	12,831	12,831	12,831
R-squared	0.443	0.443	0.443
Year FE	YES	YES	YES
Firm FE	YES	YES	YES

p-value in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

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TABLE 5 (Continued)

Panel B: The Effect of Insider Knowledge on Forecast Errors

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*	(3) *Forecast Error*
Insider	**-0.023****		**-0.027*****
	(0.010)		**(0.010)**
Outsider		-0.007	0.009
		(0.558)	(0.490)
Network_Edu	-0.012***	-0.013***	-0.013***
	(0.006)	(0.003)	(0.005)
Network_Soc	-0.024***	-0.025***	-0.024***
	(0.002)	(0.002)	(0.002)
Tenure	-0.006***	-0.006***	-0.006***
	(0.002)	(0.003)	(0.002)
Age	0.005***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)
Inst_Own	-0.066***	-0.065***	-0.066***
	(0.000)	(0.000)	(0.000)
Ind_Directors	-0.084	-0.079	-0.088
	(0.261)	(0.292)	(0.239)
#Analyst	-0.112***	-0.112***	-0.111***
	(0.000)	(0.000)	(0.000)
Loss	0.273***	0.272***	0.273***
	(0.000)	(0.000)	(0.000)
Increase	0.074***	0.074***	0.074***
	(0.000)	(0.000)	(0.000)
Earn_Volatility	1.102***	1.101***	1.100***
	(0.000)	(0.000)	(0.000)
Ret_Volatility	2.035**	1.960**	2.051**
	(0.015)	(0.019)	(0.014)
Firm Size	-0.180***	-0.183***	-0.180***
	(0.000)	(0.000)	(0.000)
Growth	-0.038***	-0.038***	-0.038***
	(0.000)	(0.000)	(0.000)
Horizon	0.004***	0.004***	0.004***
	(0.000)	(0.000)	(0.000)
Observations	19,636	19,636	19,636
R-squared	0.425	0.425	0.425
Year FE	YES	YES	YES
Firm FE	YES	YES	YES

This table reports the results for an OLS regression examining the source of knowledge spillover effect of CEO network. Panel A provides industry knowledge effect and Panel B presents insider knowledge effect. Descriptions of each variable can be found in the Appendix B. (*** Significant at two-tailed $p < 0.01$; ** Significant at two-tailed $p < 0.05$; * Significant at two-tailed $p < 0.10$.)

TABLE 6
Cross Sectional Tests Across Underlying Economic Conditions

Panel A: Systematic versus Idiosyncratic Earnings

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*
Network_Emp	-0.023**	-0.029***
	(0.022)	(0.004)
Network_Emp*Ind._Earn_Corr	**-0.030****	
	(0.047)	
Network_Emp*Mkt._Earn_Corr		**-0.048*****
		(0.003)
Ind._Earn_Corr	0.170**	
	(0.023)	
Mkt._Earn_Corr		0.259***
		(0.001)
Network_Edu	-0.012***	-0.012***
	(0.008)	(0.006)
Network_Soc	-0.022***	-0.022***
	(0.004)	(0.005)
Tenure	-0.006***	-0.006***
	(0.002)	(0.002)
Age	0.005***	0.005***
	(0.000)	(0.000)
Inst_Own	-0.066***	-0.066***
	(0.000)	(0.000)
Ind_Directors	-0.100	-0.101
	(0.186)	(0.180)
#Analyst	-0.111***	-0.110***
	(0.000)	(0.000)
Loss	0.276***	0.276***
	(0.000)	(0.000)
Increase	0.074***	0.074***
	(0.000)	(0.000)
Earn_Volatility	1.048***	1.109***
	(0.000)	(0.000)
Ret_Volatility	1.936**	1.872**
	(0.023)	(0.028)
Firm Size	-0.184***	-0.181***
	(0.000)	(0.000)
Growth	-0.038***	-0.038***
	(0.000)	(0.000)
Horizon	0.004***	0.004***
	(0.000)	(0.000)
Observations	19,341	19,341
R-squared	0.427	0.427
Year FE	YES	YES
Firm FE	YES	YES

p-value in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

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TABLE 6 (Continued)

Panel B: Underlying Uncertainty

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*
Network_Emp	-0.024**	-0.026**
	(0.015)	(0.010)
Network_Emp*Dispersion_Quintile	**-0.023***	
	(0.064)	
Network_Emp*Dispersion_Decile		**-0.044*****
		(0.010)
Dispersion_Quintile	0.261***	
	(0.000)	
Dispersion_Decile		0.405***
		(0.000)
Loss	0.257***	0.261***
	(0.000)	(0.000)
Network_Edu	-0.012***	-0.011**
	(0.007)	(0.011)
Network_Soc	-0.025***	-0.024***
	(0.001)	(0.002)
Tenure	-0.006***	-0.006***
	(0.000)	(0.000)
Age	0.005***	0.005***
	(0.000)	(0.000)
Inst_Own	-0.056***	-0.058***
	(0.001)	(0.001)
Ind_Directors	-0.059	-0.067
	(0.422)	(0.363)
#_analyst	-0.121***	-0.116***
	(0.000)	(0.000)
Increase	0.075***	0.075***
	(0.000)	(0.000)
Earn_Volatility	1.108***	1.135***
	(0.000)	(0.000)
Ret_Volatility	1.417*	1.313
	(0.089)	(0.115)
Firm Size	-0.198***	-0.200***
	(0.000)	(0.000)
Growth	-0.039***	-0.039***
	(0.000)	(0.000)
Horizon	0.004***	0.004***
	(0.000)	(0.000)
Observations	19,345	19,345
R-squared	0.431	0.431
Year FE	YES	YES
Firm FE	YES	YES

p-value in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

(Continued on Next Page)

TABLE 6 (Continued)

Panel C: Competition

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*
Network_Emp	-0.022**	-0.023**
	(0.036)	(0.023)
Network_Emp*Competition_Quintile	**-0.027****	
	(0.041)	
Network_Emp*Competition_Decile		**-0.046****
		(0.012)
Competition_Quintile	0.118*	
	(0.087)	
Competition_Decile		0.250***
		(0.008)
Loss	0.280***	0.280***
	(0.000)	(0.000)
Network_Edu	-0.012***	-0.012***
	(0.007)	(0.008)
Network_Soc	-0.024***	-0.023***
	(0.003)	(0.004)
Tenure	-0.006***	-0.006***
	(0.002)	(0.002)
Age	0.005***	0.005***
	(0.000)	(0.000)
Inst_Own	-0.064***	-0.064***
	(0.000)	(0.000)
Ind_Directors	-0.066	-0.067
	(0.387)	(0.380)
#_analyst	-0.110***	-0.111***
	(0.000)	(0.000)
Increase	0.073***	0.073***
	(0.000)	(0.000)
Earn_Volatility	1.022***	0.974***
	(0.000)	(0.001)
Ret_Volatility	2.093**	1.981**
	(0.015)	(0.021)
Firm Size	-0.186***	-0.187***
	(0.000)	(0.000)
Growth	-0.038***	-0.038***
	(0.000)	(0.000)
Horizon	0.004***	0.004***
	(0.000)	(0.000)
Observations	19,188	19,188
R-squared	0.408	0.408
Year FE	YES	YES
Firm FE	YES	YES

This table reports the results for an OLS regression examining underlying economic conditions where external information is more beneficial. Panel A provides the results related to systematic and idiosyncratic earnings that are proxied by Ind._Earn_corr (Mkt._Earn_Corr). Ind._Earn_corr (Mkt._Earn_Corr) denotes the correlation of ROE changes between the firm and industry at SIC2 level (Market level). Panel B presents underlying uncertainty effects and Panel C provides competition effects. Descriptions of each variable can be found in the Appendix B. (*** Significant at two-tailed $p < 0.01$; ** Significant at two-tailed $p < 0.05$; * Significant at two-tailed $p < 0.10$.)

TABLE 7
Controlling for CEO Ability

Panel A: Descriptive Statistics depending on Ability

		Low Ability		High Ability	
		Mean	Median	Mean	Median
(1)	*Network_Total*	387	246	323	201
(2)	*Network_Emp*	275	129	221	104
(3)	*Network_Edu*	107	52	98	45
(4)	*Network_Soc*	5	0	4	0
(5)	*Same_Industry*	144	61	127	55
(6)	*Different_Industry*	70	0	51	0
(7)	*Insider*	250	105	198	82
(8)	*Outsider*	24	18	24	18
(9)	Same_Industry_Percent	83%	100%	85%	100%
(10)	Insider_Percent	83%	84%	81%	82%
(11)	Director positions	1.6	1	1.4	1
(12)	Networks through outside director positions	173	51	137	31
(12)	Networks through main firm	42	32	42	31
(13)	Current Directors in the CEO firm	9	8	9	8
(14)	Companies CEO work for	5	5	5	4

Panel B: Interaction with CEO Ability

VARIABLES	(1) *Forecast Error*	(2) *Forecast Error*	(3) *Forecast Error*	(4) *Forecast Error*
Network_Emp	**-0.040*** **			**-0.033*** **
	(0.000)			**(0.004)**
*Network_Emp*Ability*	0.218***			0.191***
	(0.000)			(0.001)
Network_Edu		**-0.021*** **		**-0.016*** **
		(0.000)		**(0.002)**
*Network_Edu*Ability*		0.079***		0.056*
		(0.006)		(0.055)
Network_Soc			**-0.038*** **	**-0.036*** **
			(0.000)	**(0.000)**
*Network_Soc*Ability*			0.033	0.020
			(0.596)	(0.753)
Ability	-1.257***	-0.460***	-0.193***	-1.322***
	(0.000)	(0.000)	(0.009)	(0.000)
Observations	15,671	15,671	15,671	15,671
R-squared	0.444	0.443	0.443	0.445
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

This table reports the results for an OLS regression examining an interaction effect between CEO network and ability. Panel A presents the descriptive statistics based on the sample median of CEO ability. Panel B provides an OLS regression with *Forecast Error* as the dependent variable. Descriptions of each variable can be found in the Appendix B. (*** Significant at two-tailed $p < 0.01$; ** Significant at two-tailed $p < 0.05$; * Significant at two-tailed $p < 0.10$)

TABLE 8
2 Stage Regression Using Instrument Variables

	1st Stage Dep = Network_Total	2nd Stage Dep = Forecast_Error
Network_Total		-0.091***
		(0.000)
Ind_Network_Total	0.834***	
	(0.000)	
Tenure	-0.005***	-0.004***
	(0.001)	(0.001)
Age	-0.007***	0.002**
	(0.000)	(0.026)
Inst_Own	-0.065***	-0.084***
	(0.003)	(0.000)
Ind_Directors	1.383***	0.217***
	(0.000)	(0.000)
#Analyst	0.103***	-0.120***
	(0.000)	(0.000)
Loss	0.161***	0.401***
	(0.000)	(0.000)
Increase	0.042***	0.087***
	(0.003)	(0.000)
Earn_Volatility	2.010***	1.777***
	(0.000)	(0.000)
Ret_Volatility	3.460***	3.744***
	(0.000)	(0.000)
Firm Size	0.274***	0.035***
	(0.000)	(0.000)
Growth	0.033***	-0.020***
	(0.000)	(0.000)
Horizon	0.001***	0.003***
	(0.001)	(0.000)
R squared	27.8%	9.03%
Partial F-statistic	$F_p = 1670.01$ ($p < 0.001$)	
Partial R^2	$R^2 = 7.8\%$	
Weak identification test	Cragg-Donald Wald F = 1585.6 Stock-Yogo critical values: 10% maximal IV size 16.38 25% maximal IV size 5.53	
Hausman test	F=15.7 (p = 0.000)	

This table presents the results from a two-stage regression using the industry average CEO total network size as the instrumental variable. In the first-stage regression the dependent variable is the CEO's network size. In the second-stage regression the management forecast error is the dependent variable and the predicted value of CEO network size as the test variable. The results are robust even when we run the same IV regression on the sub-components of CEO's total network: Employment, Education, and Social.

TABLE 9
Network Effects by Quartiles

VARIABLES	(1) *Forecast Error*
Network_Quartile2	-0.002
	(0.732)
Network_Quartile3	-0.002
	(0.561)
Network_Quartile4	**-0.013***** **(0.002)**
Tenure	-0.006***
	(0.001)
Age	0.005***
	(0.000)
Inst_Own	-0.066***
	(0.000)
Ind_Directors	-0.086
	(0.251)
#Analyst	-0.112***
	(0.000)
Loss	0.272***
	(0.000)
Increase	0.075***
	(0.000)
Earn_Volatility	1.075***
	(0.000)
Ret_Volatility	1.970**
	(0.019)
Firm Size	-0.184***
	(0.000)
Growth	-0.038***
	(0.000)
Horizon	0.004***
	(0.000)
Observations	19,636
R-squared	0.425
Year FE	YES
Firm FE	YES

This table reports the results for an OLS regression examining the effect of network linearity on absolute forecast error. Descriptions of each variable can be found in the Appendix B. (*** Significant at two-tailed $p < 0.01$; ** Significant at two-tailed $p < 0.05$; * Significant at two-tailed $p < 0.10$.)